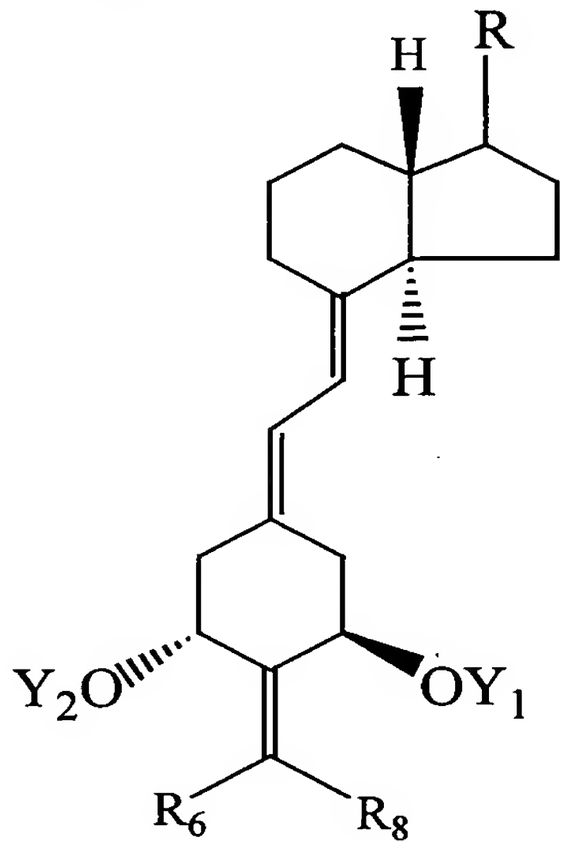
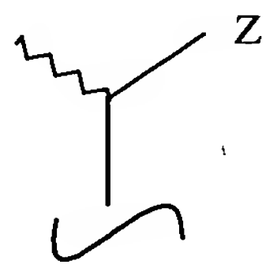
CLAIMS

We claim:

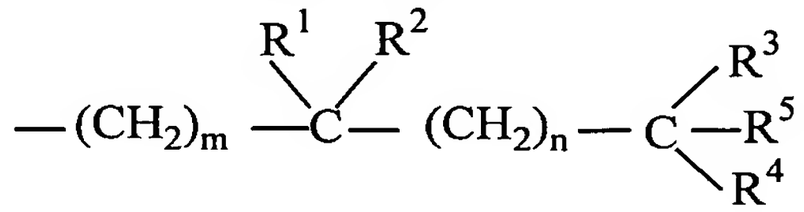
1. A compound having the formula:



where Y_1 and Y_2, which may be the same or different, are each selected from the group consisting of hydrogen and a hydroxy-protecting group, R_6 and R_8, which may be the same or different, are each selected from the group consisting of hydrogen, alkyl, hydroxyalkyl and fluoroalkyl, or, when taken together represent the group $-(CH_2)_x-$ where x is an integer from 2 to 5, and where the group R is represented by the structure:

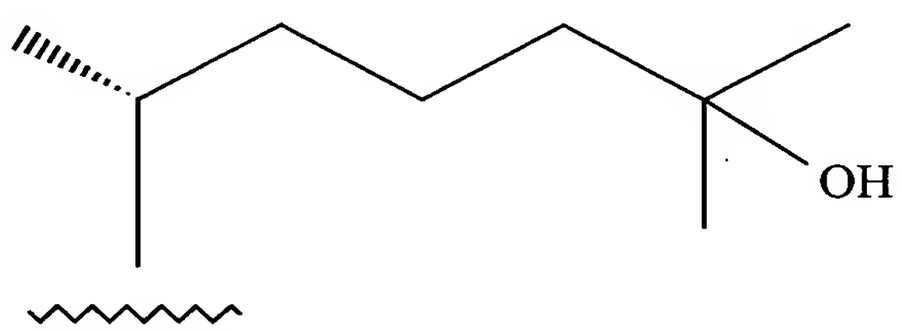


where the stereochemical center at carbon 20 may have the R or S configuration, and where Z is selected from Y, -OY, $-CH_2OY$, $-C\equiv CY$ and -CH=CHY, where the double bond may have the cis or trans geometry, and where Y is selected from hydrogen, methyl, $-COR^5$ and a radical of the structure:

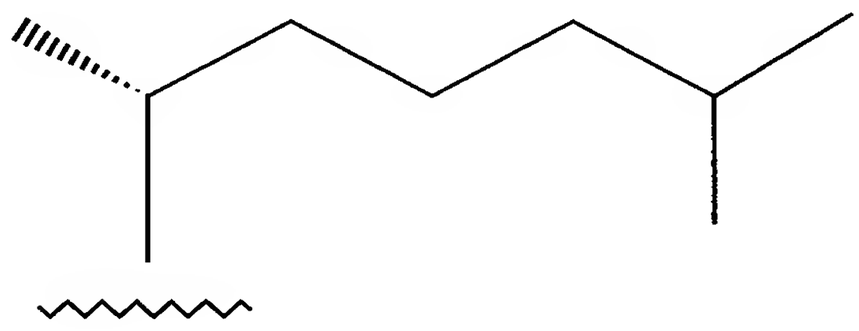


where m and n, independently, represent the integers from 0 to 5, where R^1 is selected from hydrogen, deuterium, hydroxy, protected hydroxy, fluoro, trifluoromethyl, and C_{1-5}-alkyl, which may be straight chain or branched and, optionally, bear a hydroxy or protected-hydroxy substituent, and where each of R^2, R^3, and R^4, independently, is selected from deuterium, deuteroalkyl, hydrogen, fluoro, trifluoromethyl and C_{1-5} alkyl, which may be straight-chain or branched, and optionally, bear a hydroxy or protected-hydroxy substituent, and where R^1 and R^2, taken together, represent an oxo group, or an alkylidene group, $=CR^2R^3$, or the group $-(CH_2)_p-$, where p is an integer from 2 to 5, and where R^3 and R^4, taken together, represent an oxo group, or the group $-(CH_2)_q-$, where q is an integer from 2 to 5, and where R^5 represents hydrogen, hydroxy, protected hydroxy, or C_{1-5} alkyl and wherein any of the CH-groups at positions 20, 22, or 23 in the side chain may be replaced by a nitrogen atom, or where any of the groups $-CH(CH_3)-$, $-(CH_2)m-$, $-(CH_2)n-$, or $-(CR_1R_2)-$ at positions 20, 22, and 23, respectively, may be replaced by an oxygen or sulfur atom.

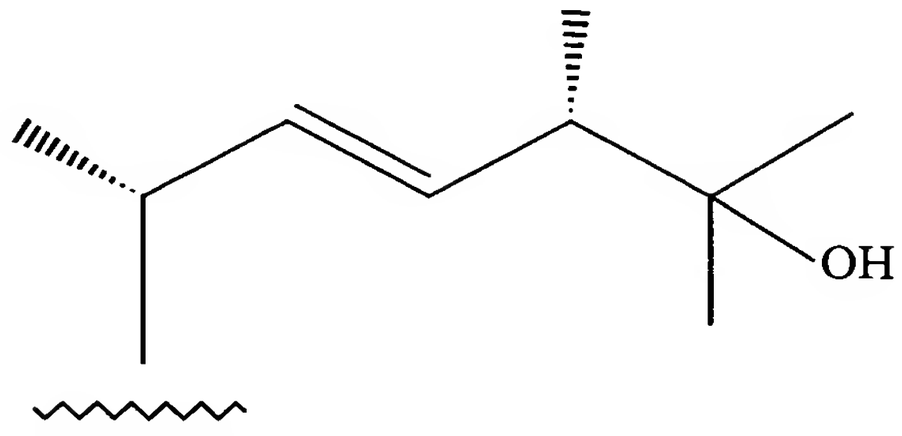
2. The compound of claim 1 where R is a side chain of the formula



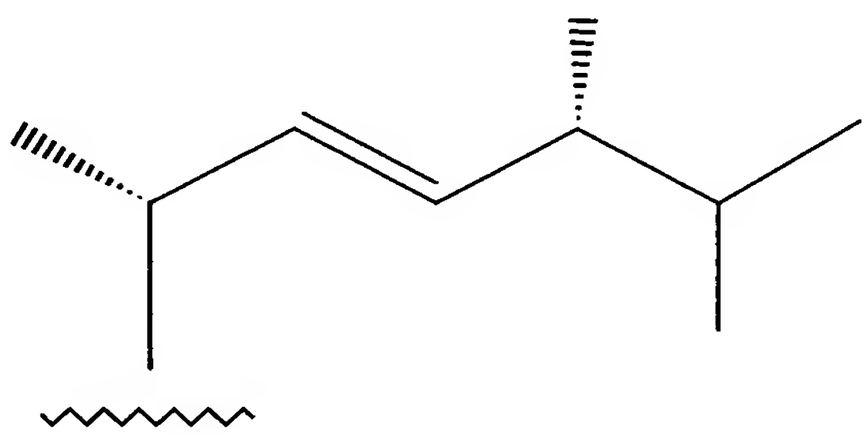
3. The compound of claim 1 where R is a side chain of the formula



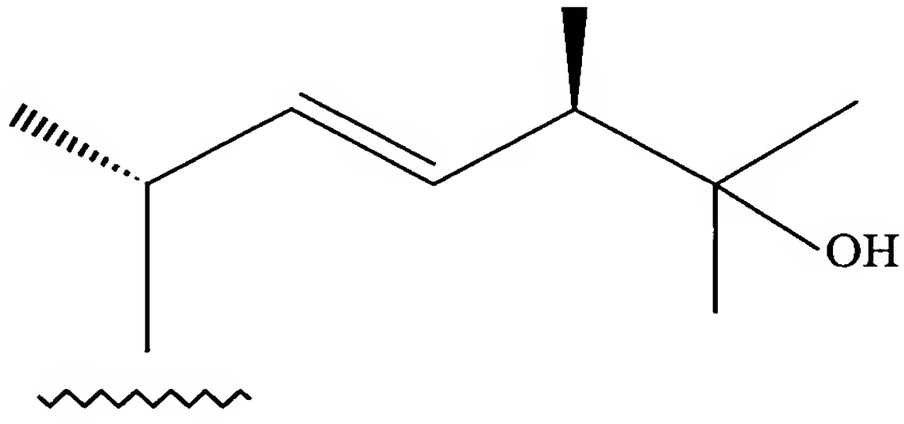
4. The compound of claim 1 where R is a side chain of the formula



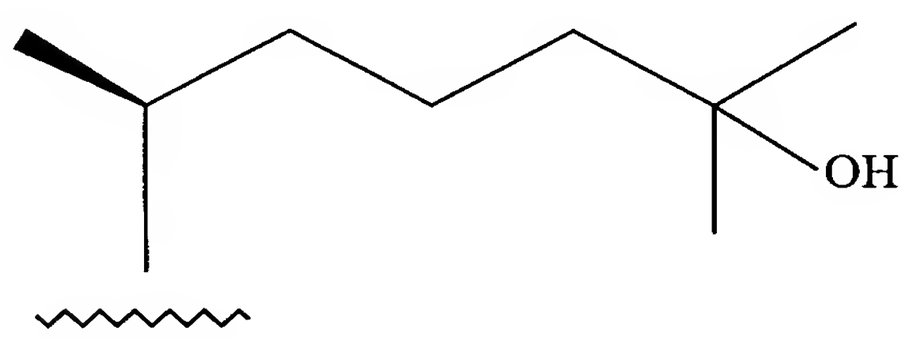
5. The compound of claim 1 where R is a side chain of the formula



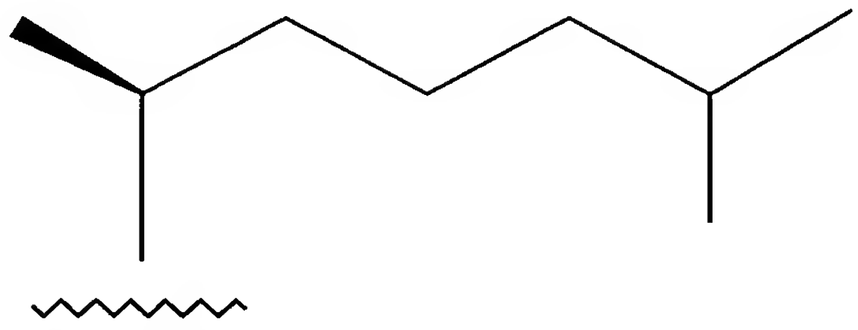
6. The compound of claim 1 where R is a side chain of the formula



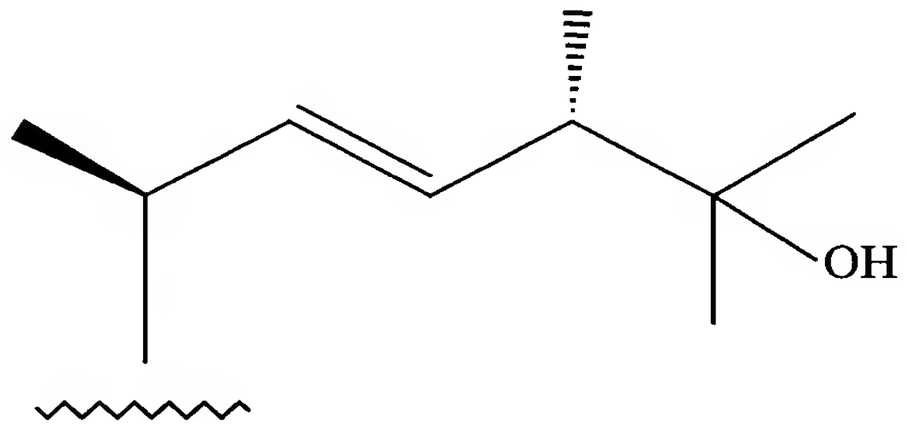
7. The compound of claim 1 where R is a side chain of the formula



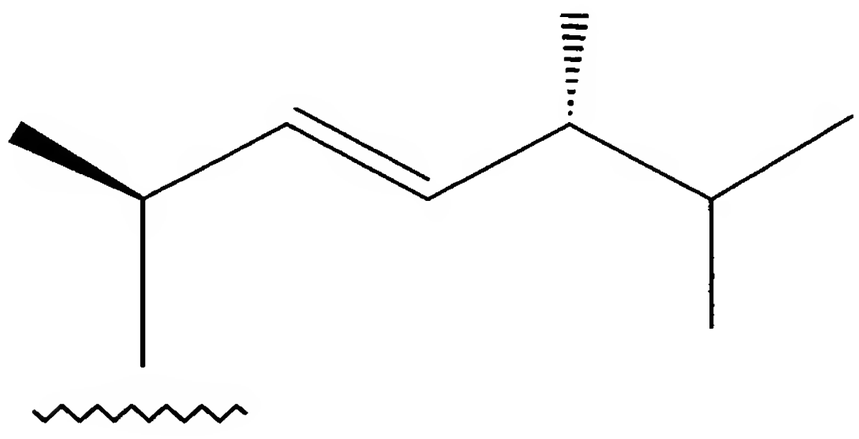
8. The compound of claim 1 where R is a side chain of the formula



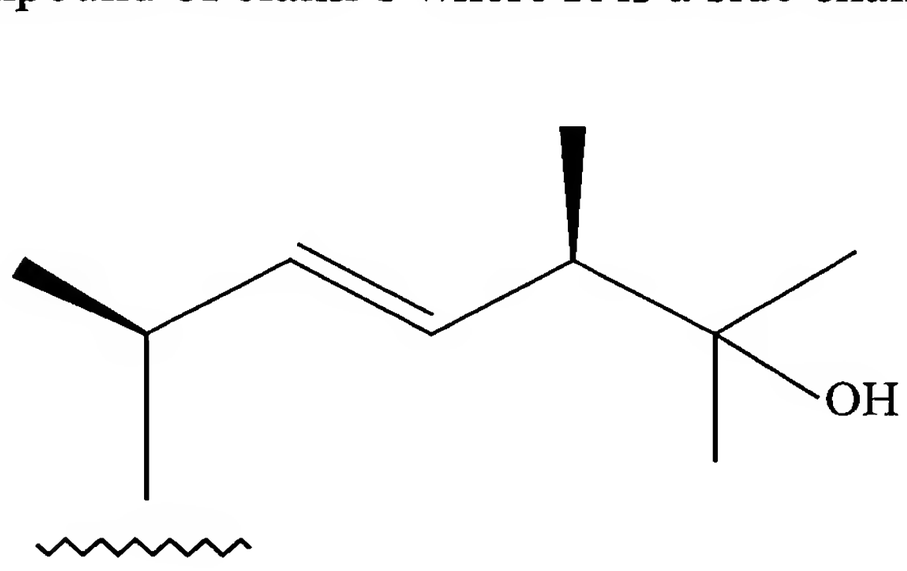
9. The compound of claim 1 where R is a side chain of the formula



10. The compound of claim 1 where R is a side chain of the formula



11. The compound of claim 1 where R is a side chain of the formula



12. (20S)-2-methylene-18,19-dinor-1α,25-dihydroxyvitamin D_3.

13. A pharmaceutical composition containing an effective amount of at least one compound as claimed in claim 1 together with a pharmaceutically acceptable excipient.

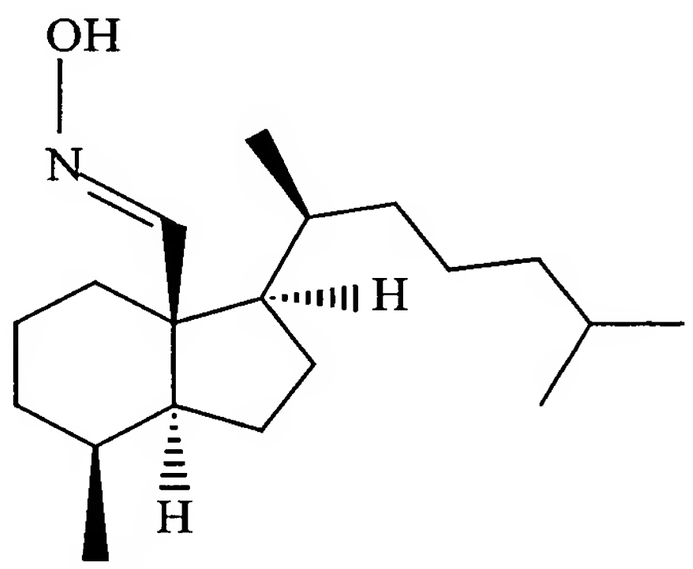
14. The pharmaceutical composition of claim 13 wherein said effective amount comprises from about 0.01μg to about 100μg per gram of composition.

15. The pharmaceutical composition of claim 13 wherein said effective amount comprises from about 0.1μg to about 50μg per gram of composition.

16. The pharmaceutical composition of claim 13 containing (20S)-2-methylene-18,19-dinor-1α,25-dihydroxyvitamin D_3 in an amount from about 0.01μg to about 100μg.

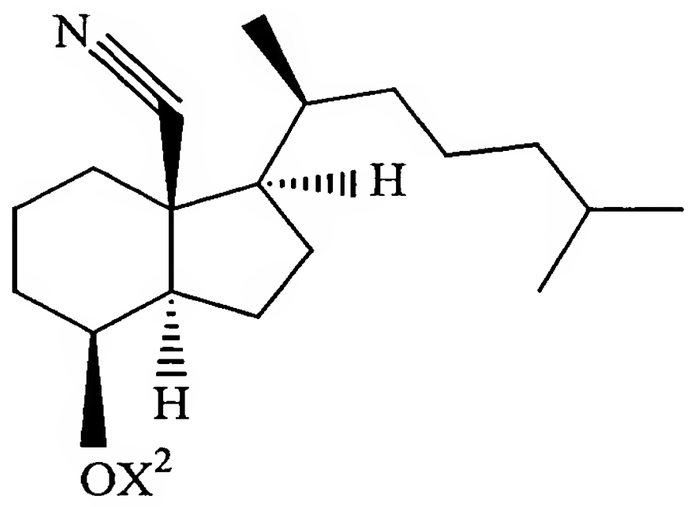
17. The pharmaceutical composition of claim 13 containing (20S)-2-methylene-18,19-dinor-1α,25-dihydroxyvitamin D_3 in an amount from about 0.1μg to about 50μg.

18. A compound having the formula:



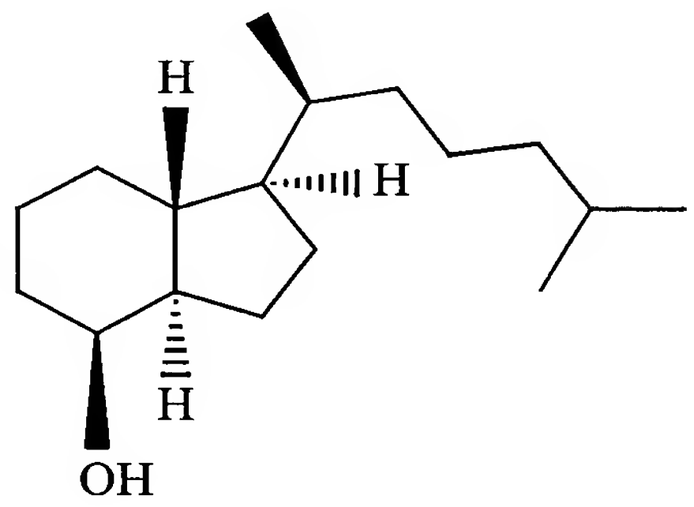
OH

19. A compound having the formula:

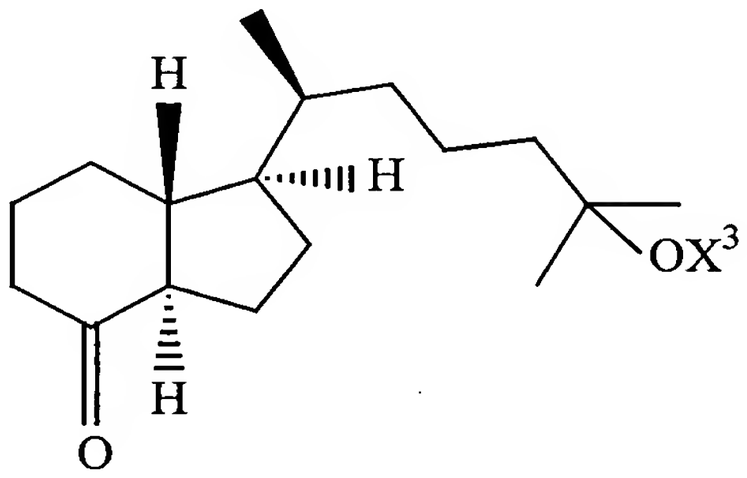


where X^2 is –H or a hydroxy protecting group.

20. A compound having the formula:

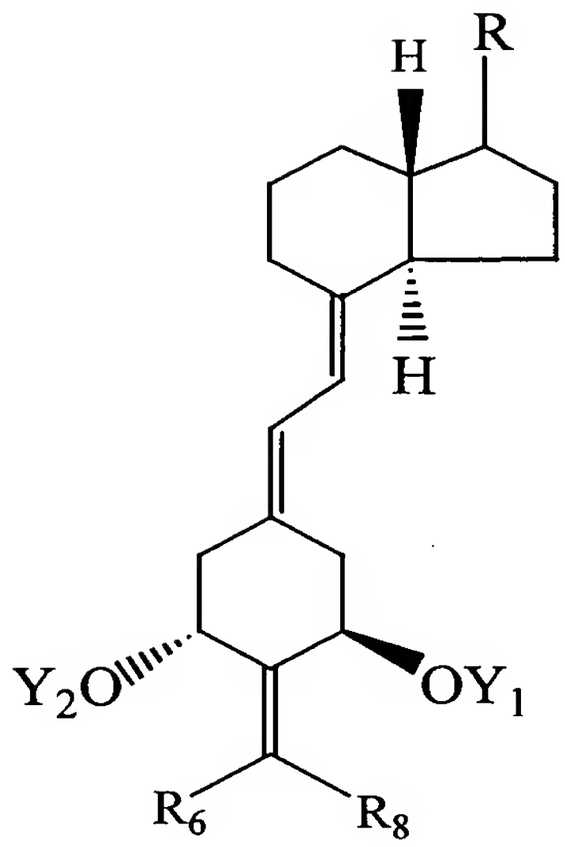


21. A compound having the formula:

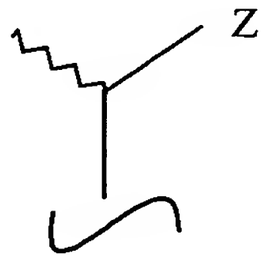


where X^3 is –H or a hydroxy protecting group.

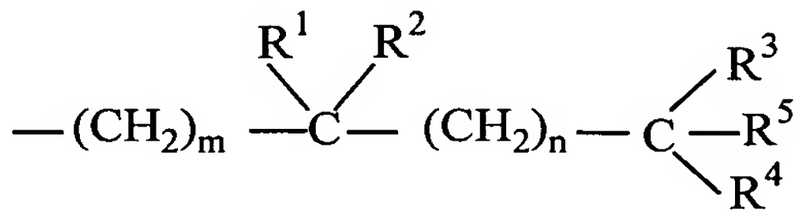
22. A method of treating metabolic bone disease where it is desired to maintain or increase bone mass comprising administering to a patient with said disease an effective amount of a compound having the formula:



where Y_1 and Y_2, which may be the same or different, are each selected from the group consisting of hydrogen and a hydroxy-protecting group, R_6 and R_8, which may be the same or different, are each selected from the group consisting of hydrogen, alkyl, hydroxyalkyl and fluoroalkyl, or, when taken together represent the group $-(CH_2)_x-$ where x is an integer from 2 to 5, and where the group R is represented by the structure:



where the stereochemical center at carbon 20 may have the R or S configuration, and where Z is selected from Y, -OY, $-CH_2OY$, -C≡CY and -CH=CHY, where the double bond may have the cis or trans geometry, and where Y is selected from hydrogen, methyl, $-COR^5$ and a radical of the structure:



where m and n, independently, represent the integers from 0 to 5, where R^1 is selected from hydrogen, deuterium, hydroxy, protected hydroxy, fluoro,

trifluoromethyl, and C_{1-5}-alkyl, which may be straight chain or branched and, optionally, bear a hydroxy or protected-hydroxy substituent, and where each of R^2, R^3, and R^4, independently, is selected from deuterium, deuteroalkyl, hydrogen, fluoro, trifluoromethyl and C_{1-5} alkyl, which may be straight-chain or branched, and optionally, bear a hydroxy or protected-hydroxy substituent, and where R^1 and R^2, taken together, represent an oxo group, or an alkylidene group, $=CR^2R^3$, or the group $-(CH_2)_p-$, where p is an integer from 2 to 5, and where R^3 and R^4, taken together, represent an oxo group, or the group $-(CH_2)_q-$, where q is an integer from 2 to 5, and where R^5 represents hydrogen, hydroxy, protected hydroxy, or C_{1-5} alkyl and wherein any of the CH-groups at positions 20, 22, or 23 in the side chain may be replaced by a nitrogen atom, or where any of the groups $-CH(CH_3)-$, $-(CH_2)_m-$, $-(CH_2)_n-$ or $-(CR_1R_2)-$ at positions 20, 22, and 23, respectively, may be replaced by an oxygen or sulfur atom.

23. The method of claim 22 where the disease is senile osteoporosis.

24. The method of claim 22 where the disease is postmenopausal osteoporosis.

25. The method of claim 22 where the disease is steroid-induced osteoporosis.

26. The method of claim 22 where the disease is low bone turnover osteoporosis.

27. The method of claim 22 where the disease is osteomalacia.

28. The method of claim 22 where the disease is renal osteodystrophy.

29. The method of claim 22 wherein the compound is administered orally.

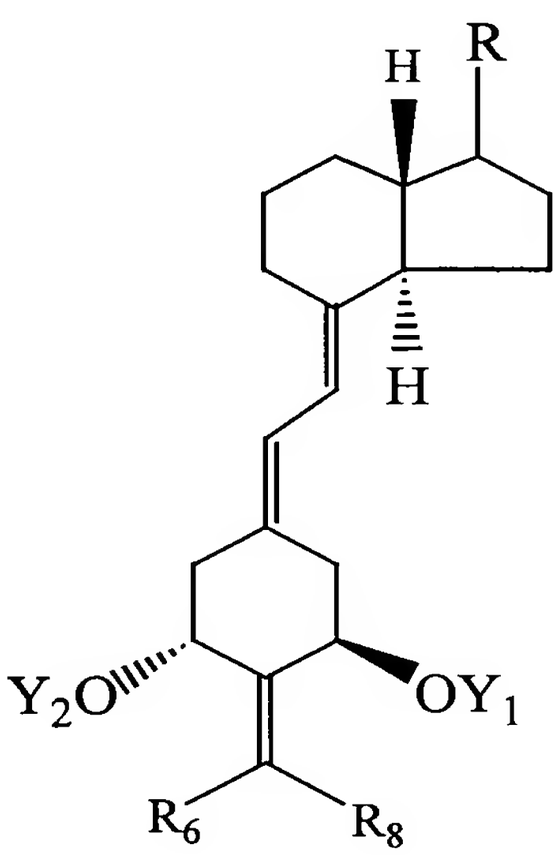
30. The method of claim 22 wherein the compound is administered parenterally.

31. The method of claim 22 wherein the compound is administered transdermally.

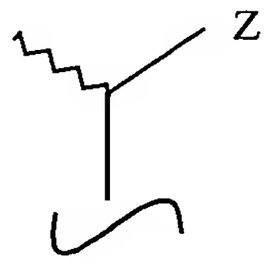
32. The method of claim 22 wherein the compound is administered in a dosage of from 0.01μg to 100μg per day.

33. The method of claim 22 wherein the compound is (20S)-2-methylene-18,19-dinor-1α,25-dihydroxyvitamin D_3.

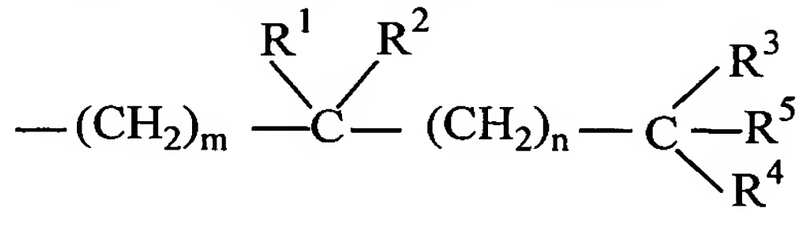
34. A method of treating psoriasis comprising administering to a patient with psoriasis an effective amount of a compound having the formula:



where Y_1 and Y_2, which may be the same or different, are each selected from the group consisting of hydrogen and a hydroxy-protecting group, R_6 and R_8, which may be the same or different, are each selected from the group consisting of hydrogen, alkyl, hydroxyalkyl and fluoroalkyl, or, when taken together represent the group $-(CH_2)_x-$ where x is an integer from 2 to 5, and where the group R is represented by the structure:



where the stereochemical center at carbon 20 may have the R or S configuration, and where Z is selected from Y, -OY, -CH_2OY, -C≡CY and -CH=CHY, where the double bond may have the cis or trans geometry, and where Y is selected from hydrogen, methyl, -COR^5 and a radical of the structure:



where m and n, independently, represent the integers from 0 to 5, where R^1 is selected from hydrogen, deuterium, hydroxy, protected hydroxy, fluoro, trifluoromethyl, and C_{1-5}-alkyl, which may be straight chain or branched and, optionally, bear a hydroxy or protected-hydroxy substituent, and where each of R^2, R^3, and R^4, independently, is selected from deuterium, deuteroalkyl, hydrogen, fluoro, trifluoromethyl and C_{1-5} alkyl, which may be straight-chain or branched, and optionally, bear a hydroxy or protected-hydroxy substituent, and where R^1 and R^2, taken together, represent an oxo group, or an alkylidene group, =CR^2R^3, or the group -$(CH_2)_p$-, where p is an integer from 2 to 5, and where R^3 and R^4, taken together, represent an oxo group, or the group -$(CH_2)_q$-, where q is an integer from 2 to 5, and where R^5 represents hydrogen, hydroxy, protected hydroxy, or C_{1-5} alkyl and wherein any of the CH-groups at positions 20, 22, or 23 in the side chain may be replaced by a nitrogen atom, or where any of the groups -$CH(CH_3)$-, -$(CH_2)_m$-, -$(CH_2)_n$- or (CR_1R_2)- at positions 20, 22, and 23, respectively, may be replaced by an oxygen or sulfur atom.

35. The method of claim 34 wherein the compound is administered orally.

36. The method of claim 34 wherein the compound is administered parenterally.

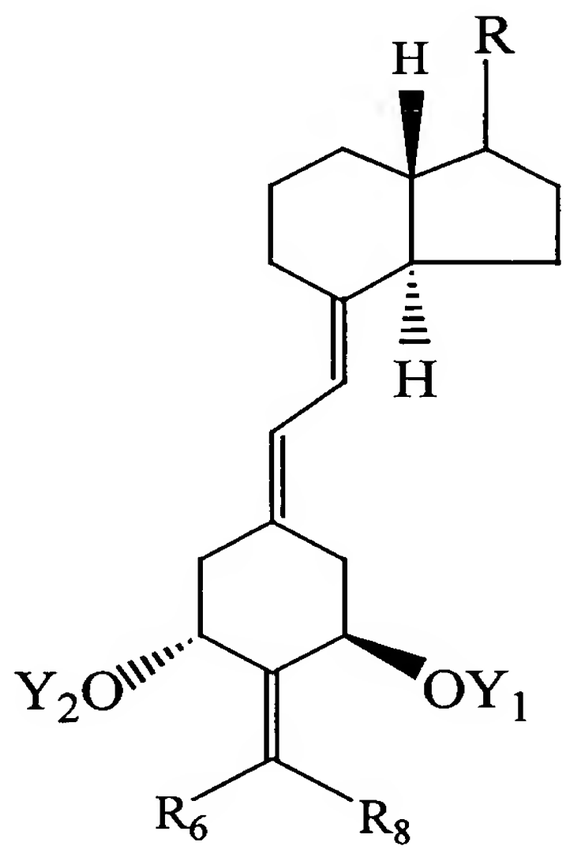
37. The method of claim 34 wherein the compound is administered transdermally.

38. The method of claim 34 wherein the compound is administered topically.

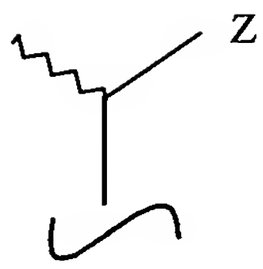
39. The method of claim 34 wherein the compound is (20S)-2-methylene-18,19-dinor-1α,25-dihydroxyvitamin D_3.

40. The method of claim 34 wherein said effective amount comprises about 0.01μg/day to about 100μg/day of said compound.

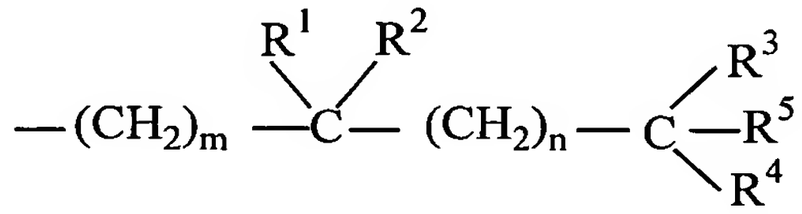
41. A method of treating leukemia, colon cancer, breast cancer, skin cancer or prostate cancer comprising administering to a patient an effective amount of a compound having the formula:



where Y_1 and Y_2, which may be the same or different, are each selected from the group consisting of hydrogen and a hydroxy-protecting group, R_6 and R_8, which may be the same or different, are each selected from the group consisting of hydrogen, alkyl, hydroxyalkyl and fluoroalkyl, or, when taken together represent the group $-(CH_2)_x-$ where x is an integer from 2 to 5, and where the group R is represented by the structure:



where the stereochemical center at carbon 20 may have the R or S configuration, and where Z is selected from Y, -OY, -CH_2OY, -C≡CY and -CH=CHY, where the double bond may have the cis or trans geometry, and where Y is selected from hydrogen, methyl, -COR^5 and a radical of the structure:



where m and n, independently, represent the integers from 0 to 5, where R^1 is selected from hydrogen, deuterium, hydroxy, protected hydroxy, fluoro, trifluoromethyl, and C_{1-5}-alkyl, which may be straight chain or branched and, optionally, bear a hydroxy or protected-hydroxy substituent, and where each of R^2, R^3, and R^4, independently, is selected from deuterium, deuteroalkyl, hydrogen, fluoro, trifluoromethyl and C_{1-5} alkyl, which may be straight-chain or branched, and optionally, bear a hydroxy or protected-hydroxy substituent, and where R^1 and R^2, taken together, represent an oxo group, or an alkylidene group, $=CR^2R^3$, or the group $-(CH_2)_p-$, where p is an integer from 2 to 5, and where R^3 and R^4, taken together, represent an oxo group, or the group $-(CH_2)_q-$, where q is an integer from 2 to 5, and where R^5 represents hydrogen, hydroxy, protected hydroxy, or C_{1-5} alkyl and wherein any of the CH-groups at positions 20, 22, or 23 in the side chain may be replaced by a nitrogen atom, or where any of the groups $-CH(CH_3)-$, $-(CH_2)_m-$, $-(CH_2)_n-$ or $(CR_1R_2)-$ at positions 20, 22, and 23, respectively, may be replaced by an oxygen or sulfur atom.

42. The method of claim 41 wherein the compound is administered orally.

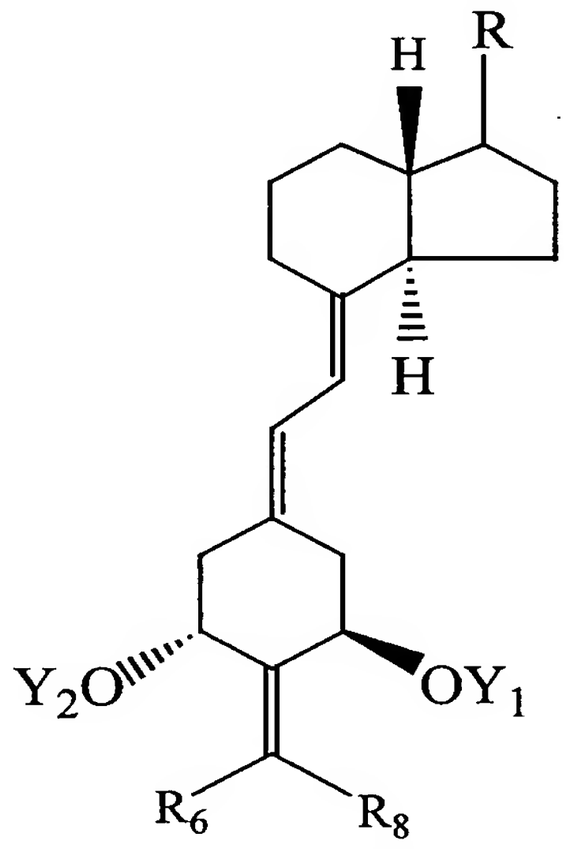
43. The method of claim 41 wherein the compound is administered parenterally.

44. The method of claim 41 wherein the compound is administered transdermally.

45. The method of claim 41 wherein the compound is administered in a dosage of from about 0.01μg/day to about 100 μg/day.

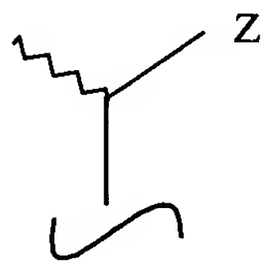
46. The method of claim 41 wherein the compound is (20S)-2-methylene-18,19-dinor-1α,25-dihydroxyvitamin D_3.

47. A method of increasing the strength of a bone comprising administering to a patient in need of such treatment an effective amount of a compound having the formula:

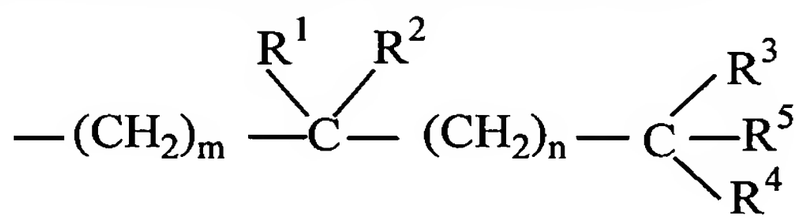


where Y_1 and Y_2, which may be the same or different, are each selected from the group consisting of hydrogen and a hydroxy-protecting group, R_6 and R_8, which may be the same or different, are each selected from the group consisting of hydrogen, alkyl, hydroxyalkyl and fluoroalkyl, or, when taken together represent

the group $-(CH_2)_x-$ where X is an integer from 2 to 5, and where the group R is represented by the structure:



where the stereochemical center at carbon 20 may have the R or S configuration, and where Z is selected from Y, -OY, $-CH_2OY$, -C≡CY and -CH=CHY, where the double bond may have the cis or trans geometry, and where Y is selected from hydrogen, methyl, $-COR^5$ and a radical of the structure:



where m and n, independently, represent the integers from 0 to 5, where R^1 is selected from hydrogen, deuterium, hydroxy, protected hydroxy, fluoro, trifluoromethyl, and C_{1-5}-alkyl, which may be straight chain or branched and, optionally, bear a hydroxy or protected-hydroxy substituent, and where each of R^2, R^3, and R^4, independently, is selected from deuterium, deuteroalkyl, hydrogen, fluoro, trifluoromethyl and C_{1-5} alkyl, which may be straight-chain or branched, and optionally, bear a hydroxy or protected-hydroxy substituent, and where R^1 and R^2, taken together, represent an oxo group, or an alkylidene group, $=CR^2R^3$, or the group $-(CH_2)_p-$, where p is an integer from 2 to 5, and where R^3 and R^4, taken together, represent an oxo group, or the group $-(CH_2)_q-$, where q is an integer from 2 to 5, and where R^5 represents hydrogen, hydroxy, protected hydroxy, or C_{1-5} alkyl and wherein any of the CH-groups at positions 20, 22, or 23 in the side chain may be replaced by a nitrogen atom, or where any of the groups $-CH(CH_3)-$, $-(CH_2)_m-$, $-(CH_2)_n-$ or $(CR_1R_2)-$ at positions 20, 22, and 23, respectively, may be replaced by an oxygen or sulfur atom.

48. The method of claim 47 wherein the bone strength is cortical strength.

49. The method of claim 47 wherein the bone strength is trabecular strength.

50. The method of claim 47 wherein the compound is administered orally.

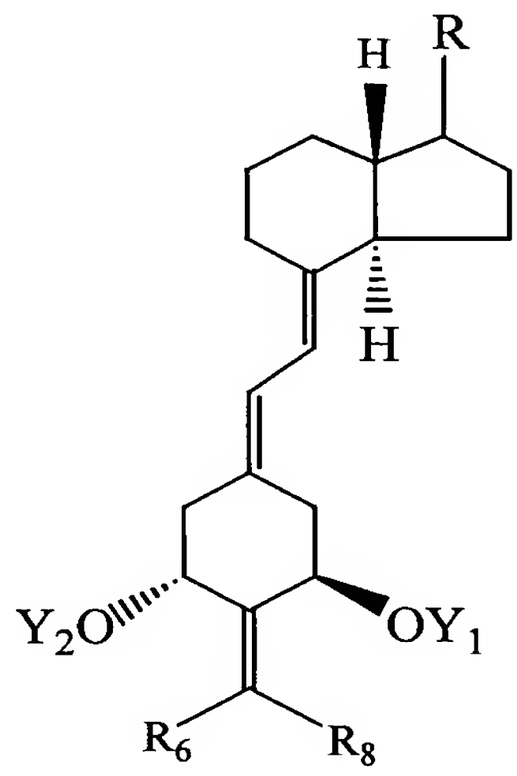
51. The method of claim 47 wherein the compound is administered parenterally.

52. The method of claim 47 wherein the compound is administered transdermally.

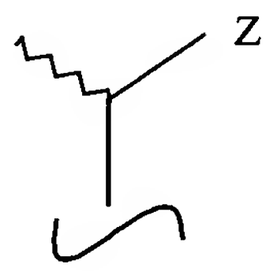
53. The method of claim 47 wherein the compound is administered in a dosage of from 0.01μg to 100μg per day.

54. The method of claim 47 wherein the compound is (20S)-2-methylene-18,19-dinor-1α,25-dihydroxyvitamin D_3.

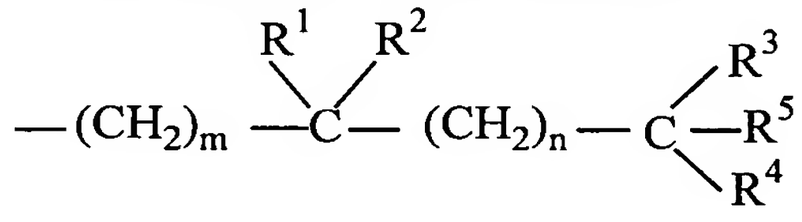
55. A method of treating an autoimmune disease comprising administering to a patient with said disease an effective amount of a compound having the formula



where Y_1 and Y_2 which may be the same or different, are each selected from the group consisting of hydrogen and a hydroxy-protecting group, R_6 and R_8, which may be the same or different, are each selected from the group consisting of hydrogen, alkyl, hydroxyalkyl and fluoroalkyl, or, when taken together represent the group $-(CH_2)_x-$ where x is an integer from 2 to 5, and where the group R is represented by the structure:



where the stereochemical center at carbon 20 may have the R or S configuration, and where Z is selected from Y, -OY, $-CH_2OY$, -C≡CY and -CH=CHY, where the double bond may have the cis or trans geometry, and where Y is selected from hydrogen, methyl, $-COR^5$ and a radical of the structure:



where m and n, independently, represent the integers from 0 to 5, where R^1 is selected from hydrogen, deuterium, hydroxy, protected hydroxy, fluoro, trifluoromethyl, and C_{1-5}-alkyl, which may be straight chain or branched and, optionally, bear a hydroxy or protected-hydroxy substituent, and where each of R^2, R^3, and R^4, independently, is selected from deuterium, deuteroalkyl, hydrogen, fluoro, trifluoromethyl and C_{1-5} alkyl, which may be straight-chain or branched, and optionally, bear a hydroxy or protected-hydroxy substituent, and where R^1 and R^2, taken together, represent an oxo group, or an alkylidene group, $=CR^2R^3$, or the group $-(CH_2)_p-$, where p is an integer from 2 to 5, and where R^3 and R^4, taken together, represent an oxo group, or the group $-(CH_2)_q-$, where q is an integer from 2 to 5, and where R^5 represents hydrogen, hydroxy, protected hydroxy, or C_{1-5}

alkyl and wherein any of the CH-groups at positions 20, 22, or 23 in the side chain may be replaced by a nitrogen atom, or where any of the groups -CH(CH_3)-, -(CH_2)m-, -(CH_2)n-, or –(CR_1R_2)- at positions 20, 22, and 23, respectively, may be replaced by an oxygen or sulfur atom.

56. The method of claim 55 where the disease is multiple sclerosis.

57. The method of claim 55 where the disease is diabetes mellitus.

58. The method of claim 55 where the disease is lupus.

59. The method of claim 55 wherein the compound is administered orally.

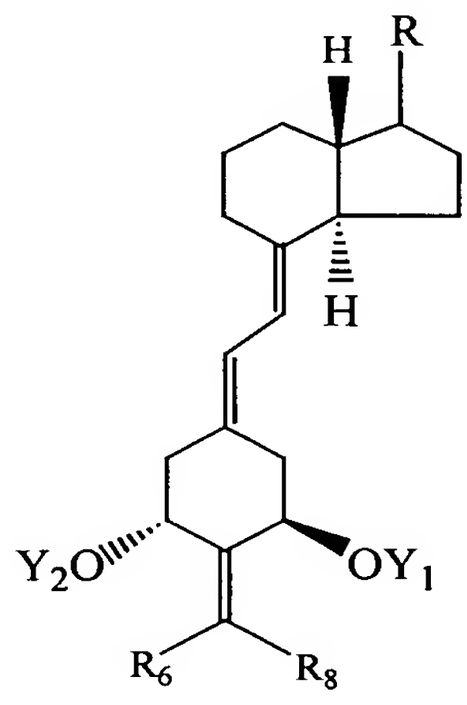
60. The method of claim 55 wherein the compound is administered parenterally.

61. Them method of claim 55 wherein the compound is administered transdermally.

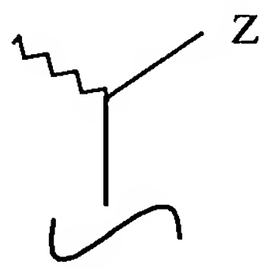
62. The method of claim 55 wherein the compound is administered in a dosage of from about 0.01 μg/day to about 100 μg/day.

63. The method of claim 55 wherein the compound is (20S)-2-methylene-18,19-dinor-1α,25-dihydroxyvitamin D_3.

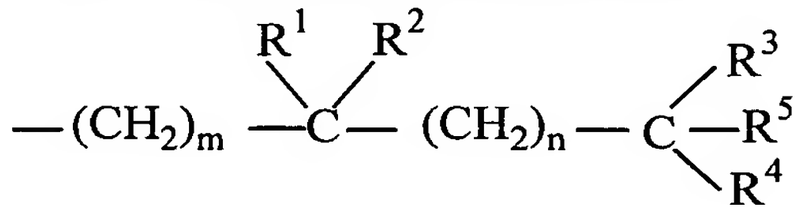
64. A method of treating an inflammatory bowel disease comprising administering to a patient with said disease an effective amount of a compound having the formula



where Y_1 and Y_2 which the same or different, are each selected from the group consisting of hydrogen and a hydroxy-protecting group, R_6 and R_8, which may be the same or different, are each selected from the group consisting of hydrogen, alkyl, hydroxyalkyl and fluoroalkyl, or, when taken together represent the group $-(CH_2)_x-$ where x is an integer from 2 to 5, and where the group R is represented by the structure:



where the stereochemical center at carbon 20 may have the R or S configuration, and where Z is selected from Y, -OY, $-CH_2OY$, -C≡CY and -CH=CHY, where the double bond may have the cis or trans geometry, and where Y is selected from hydrogen, methyl, $-COR^5$ and a radical of the structure:



where m and n, independently, represent the integers from 0 to 5, where R^1 is selected from hydrogen, deuterium, hydroxy, protected hydroxy, fluoro, trifluoromethyl, and C_{1-5}-alkyl, which may be straight chain or branched and, optionally, bear a hydroxy or protected-hydroxy substituent, and where each of R^2, R^3, and R^4, independently, is selected from deuterium, deuteroalkyl, hydrogen, fluoro, trifluoromethyl and C_{1-5} alkyl, which may be straight-chain or branched, and optionally, bear a hydroxy or protected-hydroxy substituent, and where R^1 and R^2, taken together, represent an oxo group, or an alkylidene group, $=CR^2R^3$, or the group $-(CH_2)_p-$, where p is an integer from 2 to 5, and where R^3 and R^4, taken together, represent an oxo group, or the group $-(CH_2)_q-$, where q is an integer from 2 to 5, and where R^5 represents hydrogen, hydroxy, protected hydroxy, or C_{1-5}

alkyl and wherein any of the CH-groups at positions 20, 22, or 23 in the side chain may be replaced by a nitrogen atom, or where any of the groups -CH(CH_3)-, -(CH_2)m-, -(CH_2)n-, or –(CR_1R_2)- at positions 20, 22, and 23, respectively, may be replaced by an oxygen or sulfur atom.

65. The method of claim 64 wherein the disease is Crohn's disease.

66. The method of claim 64 wherein the disease is ulcerative colitis.

67. The method of claim 64 wherein the compound is administered orally.

68. The method of claim 64 wherein the compound is administered parenterally.

69. The method of claim 64 wherein the compound is administered transdermally.

70. The method of claim 64 wherein the compound is administered in a dosage of from about 0.01 μg/day to about 100 μg/day.

71. The method of claim 64 wherein the compound is (20S)-2-methylene-18,19-dinor-1α,25-dihydroxyvitamin D_3.